CAAM 334

MATRIX ANALYSIS IN DATA SCIENCE

Spring 2021 · Rice University

Lectures:	MWF 9:45AM - 10:40AM (fully online), Zoom ID: 950 0229 4169, Passcode: 9i440b
Instructor:	Mario Bencomo (mjb6@rice.edu) Office hours: Fridays 4:00PM - 5:00PM, Zoom ID: 929 6167 8820, Passcode: 911718
Teaching Assistant:	Samuel Kroger (sak8@rice.edu) Office hours: Mondays 5:00PM - 6:00PM, Zoom ID: 969 1794 6155, Passcode: 681973
Webpage:	https://canvas.rice.edu/courses/38998

Course summary

This is an introductory linear algebra course with some applications in data science. We will go over solutions of linear systems, the Fundamental Theorem of Linear Algebra, linear least squares problems, eigenvalues and eigenvectors of matrices, singular value decomposition, and several application problems. Computational examples and considerations will also be explored, primarily through Matlab/Python.

Learning outcomes

- ◇ Mathematical literacy, in particular in the field of linear algebra.
- ◇ Theoretical and practical knowledge for solving linear algebra problems.
- ◇ Working knowledge of LaTeX.

Prerequisites

- ◇ Multivariable calculus (MATH 212 or MATH 222) and basic Matlab/Python programming skills (CAAM 210 or COMP 140).
- ◇ Cannot register for CAAM 334 if student has credit for CAAM 335.

Text

- ◇ *Lecture Notes for CAAM 334/335: Matrix Analysis*, Fall 2020 (available on Canvas)
- ◇ *Linear Algebra in Situ*, January 20201 edition (available on Canvas)

Lectures

Lectures will be recorded live using Zoom and posted on Canvas. Participants should mute both video and audio during passive participation. Questions are encouraged and will be addressed with the "raise hand" or chat Zoom features, at which point the student may directly (with audio) or via chat ask a question. Students are expected to complete relevant reading assignments ahead of lectures. Attendance is highly recommended though not enforced. The instructor reserves the right to enforce attendance later in the semester, especially if unjustified low attendance is observed.

House-Calls

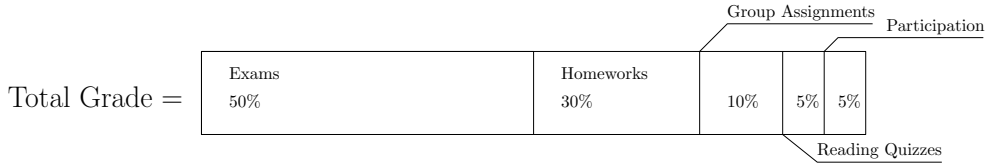
The purpose of house-calls is to replace the traditional recitation. In particular, small groups of students will meet for 30min once a week with the instructor/TA for some active learning activities. This may include reviewing lecture content, working on extra problem sets, or addressing questions from students. Students are expected to have familiarized themselves with relevant course content prior to the house-call, though mastery of the subject matter is not required.

Canvas

Canvas will be the primary and sole source for course content. All assignments will be administered and graded through Canvas.

Assignments and Grades

◇ Total grade breakdown:



Letter grades are assigned based on standard grade distributions.

◇ *Exams:* Three exams will be administered throughout the semester (including finals week):

$$15\%(\text{Exam 1}) + 15\%(\text{Exam 2}) + 20\%(\text{Exam 3}) = 50\%.$$

◇ *Homeworks:* Weekly assignments consisting of theoretical and computational problem sets. Collaboration is strongly encouraged, however, submitted write-ups must be individual's own work; see honor code policy below for a statement on plagiarism. Computational problems will require programming in Matlab/Python and submission of code for verification.

- ▶ Posted every Friday and due the following Friday before 11:59PM (CST), unless stated otherwise.

◇ *Group Assignments:* Groups or 3 to 5 students will be assigned during the first week of classes by the instructor using information from the *beginning of the semester survey*. Group assignments will consist of short questions designed to encourage collaboration and group learning. Groups should meet for discussions and rotate weekly on a representative in-charge of typing and submitting the group response. It is the students' responsibility to manage their group and complete assignments. Contact the instructor in case of serious group issues or if group shrinks to two or less members due to students dropping out.

- ▶ Posted every Friday and due the following Friday before 11:59PM (CST), unless stated otherwise.

◇ *Reading Quizzes:* Administered as Canvas quizzes prior to lectures to ensure students are completing reading assignments. These quizzes also serve as a diagnostic tool for the instructor, and help improve students' efficiency in completing homework assignments.

- ▶ Made available on a weekly basis the prior Friday.
- ▶ Deadlines are on 9AM (CST) the day of the respective lecture.

◇ *Participation:* Students will receive participation points for filling out surveys as well as attendance and participation during house-calls. A set of participation points as related to house-calls will be distributed after each exam.

◇ Typical work week:

Sunday	
Monday	• reading quiz, 9AM (CST) • lecture, 9:45AM–10:40AM (CST)
Tuesday	
Wednesday	• reading quiz, 9AM (CST) • lecture, 9:45AM–10:40AM (CST)
Thursday	
Friday	• homework, group assignment, and reading quizzes for next week made available • reading quiz, 9AM (CST) • lecture, 9:45AM–10:40AM (CST) • homework and group assignment, 11:59PM (CST)
Saturday	

Remark: Total grade computed for homeworks, group assignments, and reading quizzes will be proportional to the assigned points, respectively.

Communication Plan

- ◇ Canvas *Announcements* will be used to communicate in mass with the entire course on updates and appropriate course content.
- ◇ Canvas *Discussions* will be used as a means for students to pose questions related to homeworks and exams, as well as content related questions, to the instructor and to the class in general if appropriate. Students are welcomed to contribute to discussions by asking or answering questions, but it will not be mandatory nor a component of their grade.
- ◇ The instructor will hold office hours throughout the semester.
- ◇ Email is the preferred and reliable line of communication with the instructor, especially for individual matters. Keep in mind that an immediate reply may not be guaranteed outside of working hours (9AM–5PM weekdays).
- ◇ In general, students should not be contacting graders via email or outside of Canvas. See the re-grading policy below for how to reach out with regards to grading concerns.

Regrading

Students are welcomed to inquire about graded assignments, either for clarification or if they suspect a mistake was made. For simple queries leave a comment on the assignment (through Canvas) and the grader/instructor will reply back. Alternatively, you may email the instructor. You have up to 2 weeks from the assignment deadline (usually 1 week after grades have been submitted) to reach out for a regrade.

Use of LaTeX

- ◇ Group assignments are to be typed up using LaTeX, unless stated otherwise.
- ◇ Homeworks and exams are NOT required to be typed up, unless stated otherwise. However, students are encouraged to submit typed up homeworks and will receive at most 5% extra-credit for doing so, though the maximum grade given will be capped at 100%.

Policies and Exemptions

- ◇ *Late Homeworks*
  Assignment time-lines are constructed to be manageable and provide structure that reinforces the lecturing schedule. In order to give students flexibility during these uncertain times, students will have the possibility of submitting up to 3 late homeworks, no later than 48hrs after the original deadline. Late assignments will be marked on Canvas to help keep track of this. Please make sure to use these options wisely, since otherwise late assignments are generally not accepted.
- ◇ *General Exemptions*
  Exemptions due to the health reasons will be considered on a case by case basis. Please contact the instructor as soon as possible.
- ◇ *Honor Code Violations and Plagiarism*
  - ▸ It is an honor code violation to submit code or solutions which have, in all or in part, been copied from another student or other non-sanctioned sources.
  - ▸ It is an honor code violation to consult solutions from previous sections of this class or any other solutions manual.
  - ▸ When collaborating on permissible assignments, we suggest that students avoid interchanging finalized solutions and instead share and discuss the mathematical concepts and problem solving approaches in order to avoid issues with plagiarism.

- ◇ *Title IX Statement*
  Rice University cares about the wellbeing and safety of students. Rice encourages any student who has experienced an incident of harassment, pregnancy discrimination, gender discrimination, or relationship, sexual, or other forms interpersonal violence to seek support through the SAFE Office. Students should be aware when seeking support on campus that most employees, including ourselves, as the instructors/TA, are required by Title IX to disclose all incidents of non-consensual interpersonal behaviors to Title IX professionals on campus who can act to support that student and meet their needs. For more information, please visit safe.rice.edu or email titleixsupport@rice.edu.
- ◇ *DSS Accommodations*
  Any student with a disability requiring accommodation in this course is encouraged to contact the instructor during the first week of class, and also to contact Disability Support Services in the Ley Student Center.

Some advice ...
Put in your due diligence, but do no isolate yourself if you need help. Do not suffer in silence.

- ◇ Reach out if you need accommodations.
- ◇ Make use of course resources, study group, office hours, house-calls.
- ◇ Manage your time wisely (work smarter not just harder).

Tentative Schedule: The following schedule is intended to give a general idea of the progression of the course. The topics for each week are tentative and subject to change with advance notice.

Block I: Introduction

- ◇ Topics: introduction to the course, matrix-vector computations, basic math proof structures

Block II: Solving $Ax = b$

- ◇ Topics: Gaussian elimination, matrix inverses, LU decomposition, determinants

Block III: Fundamental Theory

- ◇ Topics: subspaces in $\mathbb{R}^n$, range and null spaces of matrices, the four fundamental subspaces, the fundamental theorem of linear algebra (FToLA)

Block IV: Beyond the Fundamentals

- ◇ Topics: vector spaces, linear mappings, linear least squares (theory and applications), projections, Gram-Schmidt orthogonalization process, QR decomposition
- ◇ Applications: linear regression, data fitting

Block V: Eigenvalue Decomposition

- ◇ Topics: complex numbers, eigenvalues and eigenvectors, diagonalization of matrices and applications
- ◇ Applications: dynamical systems, difference equations, Google PageRank algorithm

Block VI: Singular Value Decomposition

- ◇ Topics: the singular value decomposition (SVD) of matrices, relation to FToLA, pseudo-inverses, regularized least squares
- ◇ Applications: image deconvolution, data compression